Making Invisible Connections Visible

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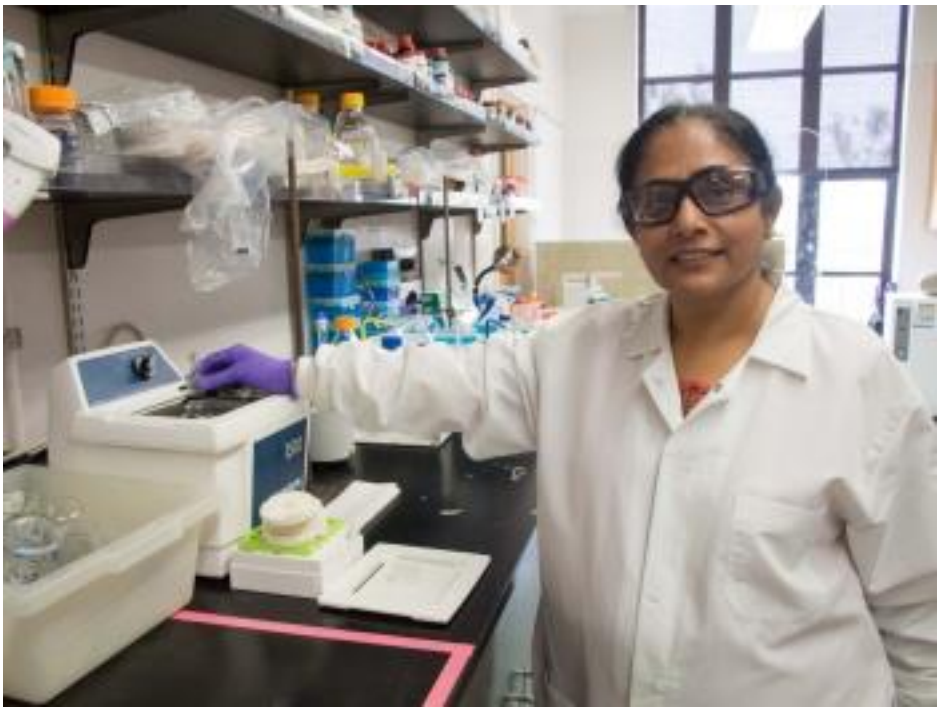

Project Overview

The concept of Intermolecular forces is explored in this two-week long unit, this work was inspired during my research project by the use of different filler agents to help the aptamers stay in a position ideal for the protein binding. Students will discover the difference in properties of three types of intermolecular forces. The driving force of electronegativity is examined in the strength of these forces. After understanding the basics the students will explore the applications of these forces in everyday chemistry. Students will learn about the effects of these IMF on various physical properties of substances. The difference in physical properties will be applied towards some of the well-known techniques like chromatography. And finally the students will get into the sticky situation of these bonds: use of these adhesive and cohesive forces in creating adhesive. The students will characterize the materials of these tapes by conducting a few tests and finally will make adhesives in lab and also characterize.

How can one explain the structure, properties, and interactions of matter?

In this unit of study, students develop and using models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they develop an understanding of the electrostatic forces at inter and intra molecular level, and provide macroscopic explanations of the atomic levels interactions of substances. Students also apply an understanding of the process of optimization and engineering design to atomic and molecular interactions. The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.

During my summer of research laboratory work in the Prof. Galen Stucky Research Group we optimized the Surface Enhanced Raman Spectroscopy (SERS) based sandwich assay for the detection of proteins. In this particular assay design, aptamer affinity pairs were chosen for their high specificity, low production cost, and robustness. These aptamers pairs and Raman tags are separately functionalized onto gold surfaces using surface modification technique. When exposed to a solution containing the protein of interest, the aptamers recognize and binds the exosites, thereby bringing the gold surfaces together to form hotspots to amplify local Raman tags. In this experiment, concentration of the Raman tags, aptamers, passivate agents, and complex media were investigated and optimized. Finally, with the optimized parameters, a standard curve was constructed with the theoretical detection limit of 10nM.

Table of Contents

Standards Addressed:

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

PS1.A: Structure and Properties of Matter

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

PS2.B: Types of Interactions

Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.*(secondary to HS-PS1-3)*

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-3)

Common Core State Standards Connections

ELA/Literacy

RST.11-12.1 - Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)

WHST.11-12.7 - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)

WHST.11-12.8 - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

WHST.11-12.9 - Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

Mathematics

HSN-Q.A.1 - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-3)

HSN-Q.A.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-3)